

**NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD**

LINED WATERWAY OR OUTLET

(feet)
CODE 468

DEFINITION

A waterway or outlet having an erosion-resistant lining of concrete, stone, synthetic turf reinforcement fabrics, or other permanent material.

PURPOSE

This practice may be applied as part of a resource management system to support one or more of the following purposes:

- Provide for safe conveyance of runoff from conservation structures or other water concentrations without causing erosion or flooding
- Stabilize existing and prevent future gully erosion
- Protect and improve water quality

CONDITIONS WHERE PRACTICE APPLIES

This practice applies if the following or similar conditions exist:

1. Concentrated runoff, steep grades, wetness, saturated conditions, prolonged base flow, seepage, or piping is such that a lining is needed to control erosion.
2. Use by people or animals precludes vegetation as suitable cover.
3. Limited space is available for design width, which requires higher velocities and lining.
4. Soils are highly erosive or other soil or climatic conditions preclude using vegetation only.
5. Stabilize overfalls in small watercourses.

CRITERIA**General Criteria Applicable To All Purposes**

General. All planned work shall comply with Federal, state, and local laws and regulations.

Lined outlets with slopes greater than 0.10 ft/ft shall meet or exceed the requirements specified for chute spillways contained in NRCS practice standard Grade Stabilization Structure (410).

Capacity. The maximum capacity of the waterway flowing at designed depth shall not exceed 200 ft³/sec. The minimum capacity shall be adequate to carry the peak rate of runoff from a 10-year, 24-hour frequency storm. Velocity shall be computed by using Manning's Formula with a coefficient of roughness "n" as follows:

Lining	"n" Value
Concrete	
Trowel finish	0.012 – 0.014
Float finish	0.013 – 0.017
Shotcrete	0.016 – 0.022
Flagstone	0.020 – 0.025
^{1/} Riprap - (Angular Rock)	$n = 0.047(D_{50} S)^{0.147}$
Synthetic Turf	Manufacturer's
Reinforcement Mats and	recommendations
Grid Pavers	

^{1/} Applies on slopes between 2 and 40% with a rock mantle thickness of $2 \times D_{50}$ where:

D_{50} = median rock diameter (in.),

S = lined section slope (ft./ft.) ($.02 \leq S \leq .4$)

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version, contact the Natural Resources Conservation Service.

Velocity. Maximum design velocity for concrete-lined sections should not exceed those using Figure 1.

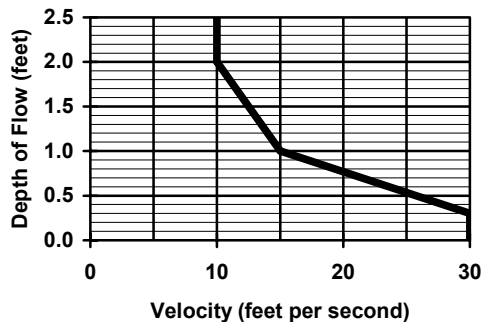


Figure 1. Maximum velocity versus depth of flow for concrete-lined channels

Maximum design velocity for synthetic turf reinforcement fabrics and grid pavers shall not exceed manufacturer's recommendations.

The design velocity for riprap shall be restricted to the safe velocity based on the D_{50} riprap size. Riprap gradations are shown on page MO-16-1, Engineering Field Handbook (NEH Part 650). [Riprap size is expressed with a subscript equal to percent smaller than. " D_{50} " equals size for which 50 percent (by weight) is smaller. " D_{100} " equals the maximum size.]

Stable rock sizes and flow depths for rock-lined channels having gradients between 2 percent and 10 percent may be determined using the following detailed design process. This design process is from **Design of Rock Chutes** by Robinson, Rice, and Kadavy.

For channel slopes between 2% and 10%:

$$D_{50} = [q(S)^{1.5}/4.75(10)^{-3}]^{0.529}$$

$$z = [n(q)/1.486(S)^{0.50}]^{0.6}$$

where:

D_{50} = Particle size for which 50% of the sample is finer, in.

S = Bed slope, ft./ft.

z = Flow depth, ft.

q = unit discharge, $\text{ft}^3/\text{s}/\text{ft}$
(Total discharge÷Bottom width)

For channel slopes greater than 10%, the outlet shall meet or exceed the requirements specified for chute spillways contained in NRCS practice standard Grade Stabilization Structure (410).

Except for short transition sections, flow in the range of 0.7 to 1.3 times the critical slope must be avoided unless the channel is straight. Velocities exceeding critical shall be restricted to straight reaches, except for discharges under 10 cubic feet per second or for velocities under 5 feet per second. When site conditions will not permit adjustment in alignment, the following criteria will apply:

1. Smooth simple curves should be used.
2. Curves will not be permitted with channel slopes in the range of 0.7 to 1.3 times critical slope (s_c).
3. Curves with channel slopes greater than 1.3 times s_c will require the following:

Concrete lining - Rectangular cross section, steel reinforcement and superelevation.*

Riprap lining - Superelevation.

*Superelevation is defined as the elevation at outer edge of the curve.

Superelevation will be added to the channel depth and will be computed by the equation.

$$S = 0.037 (V^2 T) \div R$$

where:

S = Superelevation – feet

R = radius of simple curve – feet

V = design velocity - feet per second

T = channel top width at design depth - feet

Waterways or outlets with velocities exceeding critical velocity shall discharge into an energy dissipater to reduce discharge velocity to less than critical.

Side slope. The steepest permissible side slopes, horizontal to vertical, shall be:

Lining Material	Steepest Slope H:V
Reinforced concrete	Vertical
Nonreinforced concrete:	
Hand-placed, formed concrete Height of lining, 1.5 ft or less	Vertical
Hand-placed screeded concrete or mortared in place flagstone	
Height of lining, less than 2 ft	1:1
Height of lining, more than 2 ft	2:1
Slip form concrete:	
Height of lining, less than 3 ft	1:1
Rock riprap	2:1
Synthetic Turf Reinforcement Mat	2:1
Grid Pavers	1:1

Cross section. The cross section shall be triangular, parabolic, or trapezoidal. Cross section made of monolithic concrete may be rectangular. Minimum bottom width for riprap lined channel is 6 times D_{50} size riprap but not less than 2 feet.

Freeboard. The minimum freeboard for lined waterways or outlets shall be 0.25 ft above design high water in areas where erosion-resistant vegetation cannot be grown adjacent to the paved or reinforced side slopes. No freeboard is required if vegetation can be grown and maintained.

Lining thickness. Minimum lining thickness shall be:

Lining Material	Minimum Lining Thickness
Concrete	4 in. (In most problem areas, minimum thickness shall be 5 in. reinforced concrete.)
Rock riprap	D_{100} stone size plus thickness of filter or bedding. (When a geotextile is used in lieu of a designed filter or bedding, the minimum thickness shall be 1.5 times D_{100} stone size)
Flagstone	4 in., including mortar bed.
Synthetic Turf Reinforcement Mats and Grid Pavers	Manufacturer's Recommendations

Non reinforced concrete lining durability.

Use of non-reinforced concrete or mortared flagstone linings shall be made only on low shrink-swell soils that are well drained or where subgrade drainage facilities are installed.

Rock riprap or flagstone. Stone used for riprap shall be dense and hard enough to withstand exposure to air, water, freezing, and thawing. Flagstone shall be flat for ease of placement and have the strength to resist exposure and breaking. The minimum D_{50} size rock riprap shall be 6 inches.

Geotextiles. Geotextiles shall be used where appropriate as a separator between rock, flagstone, or concrete linings and soil to prevent migration of soil particles from the subgrade, through the lining material. Geotextile shall be a non-woven needle punched fabric confirming to Missouri Construction Specification 753 Geotextile.

Filters or bedding. Filters or bedding shall be used where appropriate to prevent piping. Drains shall be used to reduce uplift pressure and to collect water, as required. Filters, bedding, and drains shall be designed according to NRCS standards. Weep holes may be used with drains if needed. Geotextile may be used in lieu of a filter or bedding.

Concrete. Concrete used for lining shall be proportioned so that it is plastic enough for thorough consolidation and stiff enough to stay in place on side slopes. Concrete and reinforcing steel shall conform to Missouri Construction Specification 750, Reinforced Concrete.

Contraction joints. Contraction joints in concrete linings, if required, shall be formed or sawed transversely to a depth of about one-third the thickness of the lining at a uniform spacing in the range of 10 to 15 feet. Provide dowel bars or other uniform support to the joint to prevent unequal settlement. Dowel bars shall be unbounded to the concrete on at least one side of the joint.

Uplift pressure. Concrete and mortared flagstone linings shall be investigated for uplift pressure. When buoyancy exceeds lining weight, uplift pressure may be a problem. Weep holes shall be installed when buoyancy cross

sectional area is 2.4 (or greater) times the lining cross sectional area and either:

1. Channel slope is 5 percent or flatter.
2. Lining depth is 2 feet or greater.

Minimum weep hole size is 3/4 inch. Weep holes over 1 inch in diameter will require a filter.

Mortar. Mortar used for mortared in-place flagstone shall consist of a workable mix of cement, sand, and water with a water-cement ratio of not more than 6 gallons of water per bag of cement.

Synthetic Turf Reinforcement Mats. When design velocities exceed 8 feet per second, the soil subsurface is expected to be soft or irregular or the material requires protection from such potential hazards as mowing or fire the material matrix shall be soil filled as part of the installation.

Related structures. Side inlets, drop structures, and energy dissipaters shall meet the hydraulic and structural requirements for the site.

Outlets. All lined waterways and outlets shall have a stable outlet with adequate capacity to prevent erosion and flooding damages.

Vegetation. Disturbed areas that are not part of the lined surface shall be established to permanent vegetation as soon as practicable after construction. Refer to Conservation Practice Standard Critical Area Planting (342) if runoff, soil, climatic conditions preclude the use of vegetation and protection against erosion is needed, non vegetative means, such as mulch or gravel may be used.

CONSIDERATIONS

Cultural resources need to be considered when planning this practice. Where appropriate, local cultural values need to be incorporated into practice design in a technically sound manner.

Consider adding widths of appropriate vegetation to the sides of the waterway for wildlife habitat.

Important wildlife habitat, such as woody cover or wetlands, should be avoided or protected if possible when siting the lined waterway. If trees

and shrubs are incorporated, they should be retained or planted in the periphery of the grassed portion of the lined waterways so they do not interfere with hydraulic functions and roots do not damage the lined portion of the waterway. Mid- or tall bunch grasses and perennial forbs may also be planted along waterway margins to improve wildlife habitat. Waterways with these wildlife features are more beneficial when connecting other habitat types; e.g., riparian areas, wooded tracts and wetlands.

Provide livestock and vehicular crossings as necessary to prevent damage to the waterway. Crossing design shall not interfere with design flow capacity.

Establish filter strips on each side of the waterway to improve water quality.

When designing riprap linings and specifying rock gradations, consider that rock delivered to the site is often segregated by size or does not conform exactly to the specified gradation. Adequate safety factor should be incorporated.

PLANS AND SPECIFICATIONS

Plans and specifications for constructing lined waterways or outlets shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose(s). Missouri standard drawings and construction specifications shall be used when available.

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be provided to and reviewed with the landowner. The plan shall include the following items and others as appropriate.

A maintenance program shall be established to maintain waterway capacity and outlet stability. Lining damaged by machinery or erosion must be repaired promptly.

Inspect lined waterways regularly, especially following heavy rains. Damaged areas shall be repaired immediately. Remove sediment deposits and debris to maintain capacity of lined waterways.

The vegetation shall be maintained and undesirable trees and brush controlled by

mechanical or other approved means. Landowners should be advised to avoid areas where forbs have been established when applying herbicides. Avoid using waterways as turn-rows during tillage and cultivation operations. Control noxious weeds. Do not use as a field road. Avoid crossing with heavy equipment.

REFERENCES

National Engineering Handbook, Part 650, Engineering Field Handbook: Chapter 16, Streambank and Shoreline Protection.

Robinson, K.M., C.E. Rice, and K.C. Kadavy. 1998. Design of Rock Chutes. Transactions of ASAE, Vol. 41(3): 621-626.

THIS PAGE LEFT BLANK ON PURPOSE

**NATURAL RESOURCES CONSERVATION SERVICE
OPERATION AND MAINTENANCE**

**FOR
LINED WATERWAY OR OUTLET
(468)**

General

Operation and maintenance shall address maintaining the lined portions, associated berms, approach channel, and outlet channel. Site should be checked every six months and after any excessive rainfall.

Any component at the site should be corrected as soon as possible to prevent major damages.

Berm

Eroded areas shall be promptly repaired and reseeded, if applicable.

Trees and woody cover generally create problems and should be controlled.

Cross sectional shape shall be corrected if substantially different than original built.

Cracking in earth berm should be corrected by determining the extent of the effected area and repairing this area with fill material.

Type of lining**Concrete**

Check for any cracking in concrete surface and determine to what depth the cracking is occurring.

Look for any exposed steel reinforcement, if applicable. If present and exposed, prepare a neat cement mixture composed of cement, sand, and water. Prepare area to be patched by chipping back to solid material, wetting the area by placing wet burlap or other moisture holding materials on the area for at least one hour prior to start of patching.

Additional details: _____

Observe the condition of any contraction joints. Consult with local office staff on ways to repair effected area.

Rock Riprap

Compare size of existing rock pieces to size of those at time of installation. (Refer to as-built drawings and specifications.) If substantially smaller in size, consider replacing rock riprap with proper size in order for lined outlet to operate as designed.

Check for overall appearance of cross sectional area. Redistribute rock pieces to reestablish proper cross sectional shape and dimensions.

Synthetic Turf Reinforcement Mat

Check for eroded areas under the mat and repair by filling with topsoil and reseeded. Replace and re anchor mat as needed.

Take precautions to protect the mat material when mowing or burning vegetation.

Outlet

Inspect condition of downstream channel for clogging in cross section (across channel).

Vegetation

The vegetation shall be maintained to prevent erosion or gullyng of the associated berm and other areas near the lined waterway site. Prescribed burning and mowing may be appropriate to enhance wildlife values, but must be conducted to avoid peak nesting seasons and reduced winter cover.

THIS PAGE LEFT BLANK ON PURPOSE

**NATURAL RESOURCES CONSERVATION SERVICE
MISSOURI CONSTRUCTION SPECIFICATION**

**FOR
LINED WATERWAY OR OUTLET
CONCRETE LINED
(468-A)**

General

Work shall consist of furnishing all labor, equipment, materials, and constructing the concrete lined waterway and appurtenances at locations shown on the drawings. Construction operations shall be carried out in a manner and sequence that erosion and air and water pollution are minimized and held within legal limits.

The completed job shall present a workmanlike appearance and shall conform to the line, grades, and elevations shown on the drawings or as staked in the field.

All operations shall be carried out in a safe and skillful manner. Safety and health regulations shall be observed and appropriate safety measures used. Contractor shall be assured that all state laws concerning buried utilities have been met.

A land disturbance permit from the Missouri Department of Natural Resources may be needed if the disturbed area is greater than one (1) acre in size.

Materials

Materials and fabrication shall be as specified herein or on the drawings.

Concrete and reinforcement steel shall conform to Missouri Construction Specification 750, Reinforced Concrete.

Excavation, fill, backfill, and finish grading

Foundation area shall be cleared of trees, stumps, roots, sod, and loose rock.

Additional details: _____

Cross section area shall be excavated to the neat lines and grades as shown on the drawings. Overexcavated areas shall be backfilled with moist soil compacted to the density of the surrounding material.

Suitable excavated material may be used as fill and backfill.

Finish grading shall consist of smoothing and grading to form a smooth uniform surface between the existing ground and the top of the concrete lining. When completed the entire disturbed area shall be ready for seeding.

Construction

Concrete lining shall be placed to the thickness, shapes, lines, and grades shown on the drawings. Abrupt deviations from line or grade shall not be permitted. Except for sections of the lined waterway designed with steel reinforcement that are to be poured in one contiguous unit, the lining shall be formed and placed in alternate sections, not to exceed fifteen (15) feet. Expansion joint filler shall be placed between each section.

Steel reinforcement will be placed at locations shown on the drawings, if applicable.

Earth surface shall be firm and damp where concrete is to be placed.

Concrete shall not be placed when the temperature is above 90°F or below 40°F. Concrete shall have a wood float finish and be immediately coated with concrete curing compound.

THIS PAGE LEFT BLANK ON PURPOSE

**NATURAL RESOURCES CONSERVATION SERVICE
MISSOURI CONSTRUCTION SPECIFICATION**

**FOR
LINED WATERWAY OR OUTLET
RIPRAP LINED
(468-B)**

General

Work shall consist of furnishing all labor, equipment, materials, and constructing the concrete lined waterway and appurtenances at locations shown on the drawings. Construction operations shall be carried out in a manner and sequence that erosion and air and water pollution are minimized and held within legal limits.

The completed job shall present a workmanlike appearance and shall conform to the line, grades, and elevations shown on the drawings or as staked in the field.

All operations shall be carried out in a safe and skillful manner. Safety and health regulations shall be observed and appropriate safety measures used. Contractor shall be assured that all state laws concerning buried utilities have been met.

A land disturbance permit from the Missouri Department of Natural Resources may be needed if the disturbed area is greater than one (1) acre in size.

Materials

Individual rock fragments should be dense, sound, and free from defects conducive to accelerated weathering. Rock fragments should be angular to subrounded in shape. The rock should have the following properties:

- a. Bulk specific gravity (saturated surface-dry basis) not less than 2.5 .
- b. Absorption not more than 2 percent.
- c. Soundness: Weight loss in 5 cycles not more than 20 percent when sodium sulphate is used or 25 percent when magnesium sulfate is used.

The rock shall conform to the specified grading limits. Flat slabs of concrete or rock shall not be used.

Subgrade preparation

Foundation area shall be cleared of trees, stumps, roots, and sod. Cross section area shall be excavated to the neat lines and grades as shown on the drawings. Overexcavated areas shall be backfilled with moist soil compacted to the density of the surrounding material.

No abrupt deviations from design grade or horizontal alignment shall be permitted.

Equipment-placed rock riprap

Rock shall be placed by equipment on the surfaces and to the depths specified. Riprap shall be placed to the full course thickness in one operation and in such a manner as to avoid serious displacement of the underlying materials.

Riprap in place shall be reasonably homogeneous with larger rocks uniformly distributed and firmly in contact one to another with the smaller rocks and spoils filling the voids between the larger rocks. Riprap shall be placed so it does not reduce the design section more than 10 percent. It is recommended that rock placement begin at the outlet section and progress upstream.

Filter or bedding layer

When the drawings specify filter layers or bedding beneath riprap, the filter or bedding material shall be spread uniformly on the prepared subgrade surfaces to the depth specified. The surface of such layers shall be finished reasonably free of mounds, dips, or windrows. The filter or bedding materials shall be hard, durable material conforming to the grading limits shown on the drawings or in the specifications.

468-12

Geotextile conforming to Missouri Construction
Specification 753 Geotextile may be used when

shown on the drawings.

Additional details: _____

**NATURAL RESOURCES CONSERVATION SERVICE
MISSOURI CONSTRUCTION SPECIFICATION**

**FOR
LINED WATERWAY OR OUTLET
Synthetic Turf Reinforcement Mat
(468-C)**

General

Work shall consist of furnishing all labor, equipment, materials, and constructing the concrete lined waterway and appurtenances at locations shown on the drawings. Construction operations shall be carried out in a manner and sequence that erosion and air and water pollution are minimized and held within legal limits.

The completed job shall present a workmanlike appearance and shall conform to the line, grades, and elevations shown on the drawings or as staked in the field.

All operations shall be carried out in a safe and skillful manner. Safety and health regulations shall be observed and appropriate safety measures used. Contractor shall be assured that all state laws concerning buried utilities have been met.

A land disturbance permit from the Missouri Department of Natural Resources may be needed if the disturbed area is greater than one (1) acre in size.

Materials

The synthetic turf reinforcement mat (TRM) shall be a long term and non-degradable rolled erosion control product composed of UV stabilized, non-degradable synthetic fibers, filaments, nettings and/or wire mesh processed into a three dimensional reinforcement matrix. The TRM shall provide sufficient thickness, strength and void space to permit soil filling and/or retention and the sprouting and rooting of vegetation within the matrix. The TRM shall meet or exceed the physical properties listed in Table 1 for the Type of TRM specified on the drawings.

TRM material shall be stored in a clean dry location, out of direct sunlight and with the manufacturer's protective cover undisturbed.

Subgrade preparation

Foundation area shall be cleared of trees, stumps, roots, and sod. Cross section area shall be excavated to the neat lines and grades as shown on the drawings. Overexcavated areas shall be backfilled with moist soil compacted to the density of the surrounding material.

No abrupt deviations from design grade or horizontal alignment shall be permitted.

Material anchoring

Unroll and install the TRM with the long dimension parallel to the primary direction of water flow. Install the TRM in header, footer and erosion stop trenches as detailed on the drawings.

Anchor the TRM using steel staples formed in "U" shapes. The staples shall be a minimum 11 gauge steel wire with a minimum leg length of 6 inches. The spacing of the staples shall be as detailed on the drawings. All splices and joints shall be oriented, lapped (or sewn), and anchored as detailed on the drawings. The upstream end or edge shall overlap on top of the downstream end or edge. Alternate anchoring and splicing methods and patterns as recommended by the manufacture may be used unless otherwise stated on the drawings.

Installation - Non soil filled matrix

The manufacturer of the TRM must recommend that not filling the TRM matrix is an approved installation method for the product.

The TRM shall be installed within 48 hours of completing the seeding of the prepared soil surface.

The TRM shall be installed on the prepared surface at the locations and in accordance with the details shown on the drawings. Unless otherwise specifically recommended by the manufacturer no equipment shall be allowed to travel on the TRM.

Installation - Soil filled matrix

The manufacturer of the TRM must recommend that soil filling of the TRM matrix is an approved installation method for the product.

Complete final grading of soil surface to the lines and grades shown on the drawings less the thickness of the TRM and the soil cover to be placed on top of it. The TRM shall be installed on the prepared surface at the

locations and in accordance with the details shown on the drawings.

After installation of the TRM, the matrix (voids) of the TRM shall be filled and covered with friable topsoil material to the depths shown on the drawings. Unless otherwise specifically recommended by the manufacturer no equipment shall be allowed to travel on the TRM and the soil shall be applied and graded by manual means.

The soil filled and covered TRM shall be seeded according to the requirements of the seeding specification.

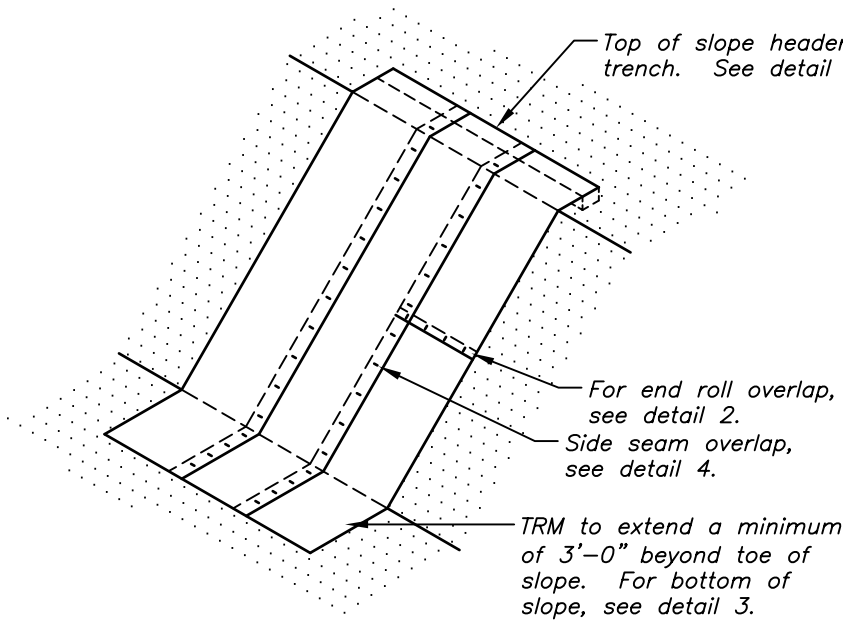
Vegetation

Refer to the JS AGRON-25 job sheet or equivalent for seeding and mulching recommendations.

TABLE 1 – Minimum Physical Requirements for TRM

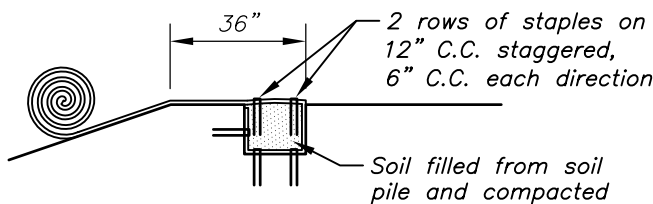
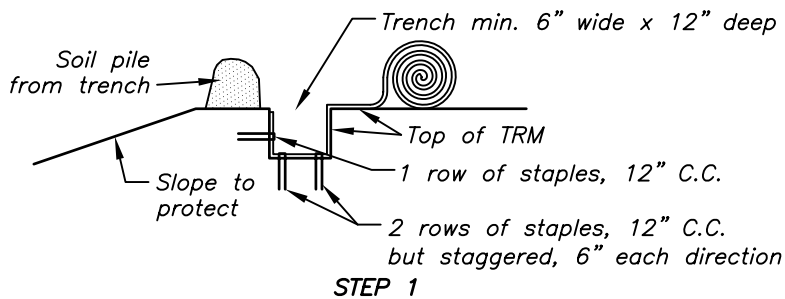
TRM Type	Minimum Unit Weight (oz/sy) ASTM D5261	Minimum Tensile Strength (psi) ASTM D6818	Minimum Thickness (in) ASTM D6525	Minimum UV Stability (%) ASTM D4355	Minimum Vegetated Shear Stress Rating (psi) ASTM D6460
Type 1	8	120	0.25	80	6
Type 2	12	160	0.50	80	8

Additional details: _____



SLOPE DETAIL

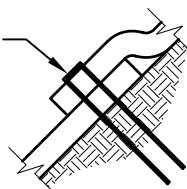
No Scale



TOP OF SLOPE HEADER TRENCH – DETAIL 1

No Scale

End seam or TRMs overlap min. 4". Place staples, one on each corner of TRM and 12" C.C. along TRM end through both TRMs. Upslope TRM laps over downslope TRM in a shingle effect.

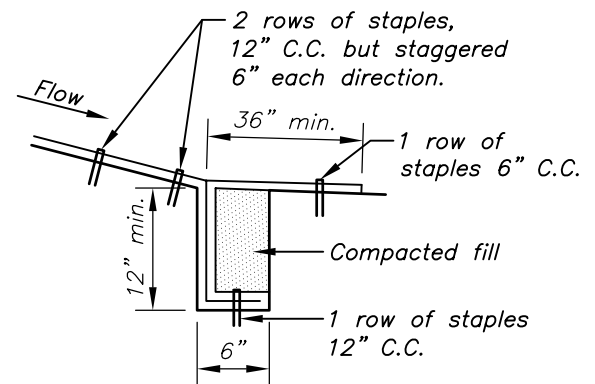


END ROLL OVERLAP DETAIL 2

No Scale

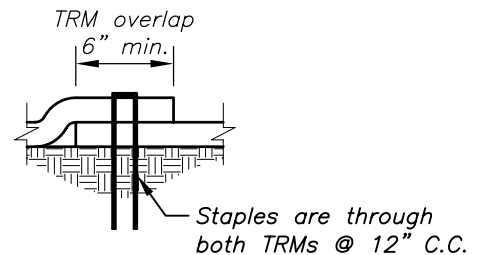
NOTES:

1. Staple patterns are dependent on site conditions. See sheet 721-5, Staple Pattern Guide for details.
2. An erosion check shall be installed if distance between header trench and downstream end trench exceeds 100 feet for slopes of 5:1 or flatter or 50 feet for slopes steeper than 5:1.



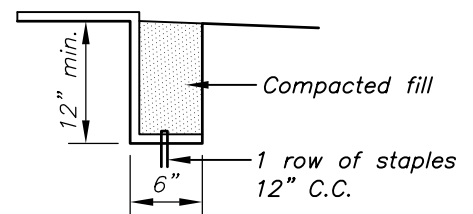
DOWNSTREAM FOOTER TRENCH AND EROSION CHECK – DETAIL 3

No Scale



SIDE SEAM OVERLAP STAPLE – DETAIL 4

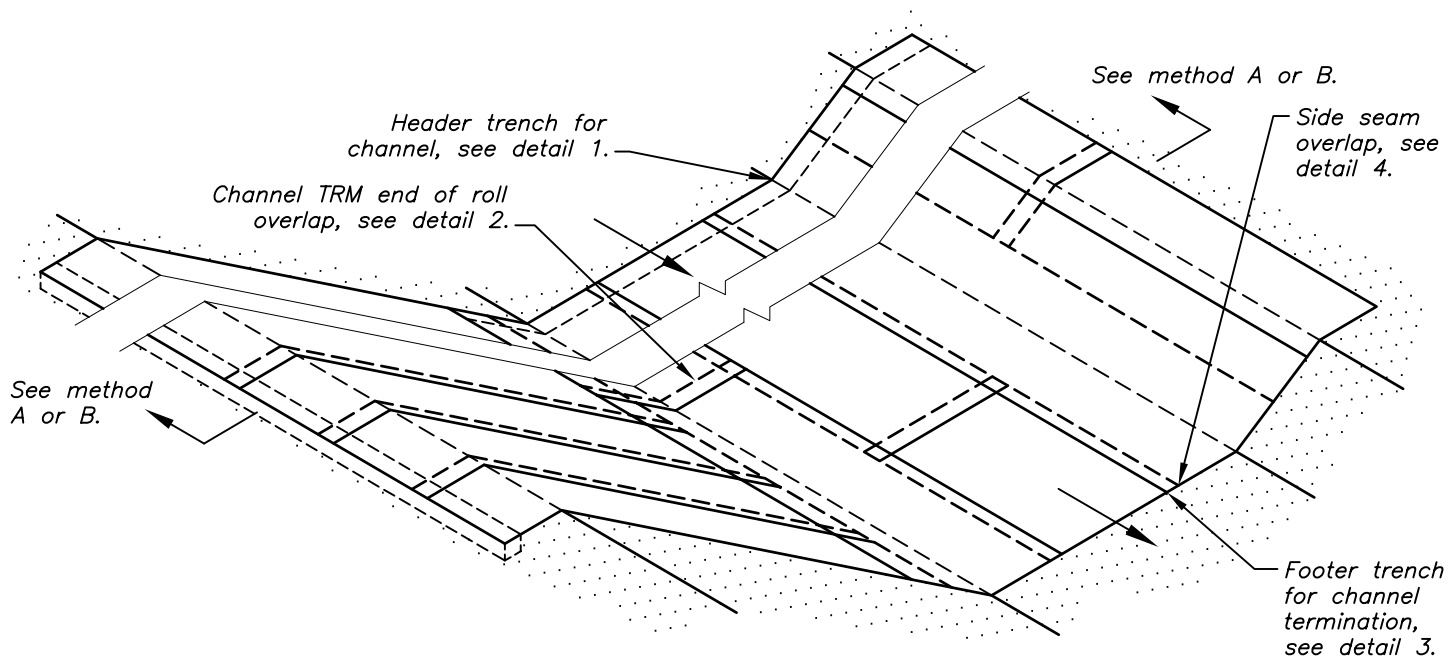
No Scale



PERIMETER EDGE TERMINATION ANCHOR TRENCH – DETAIL 5

No Scale

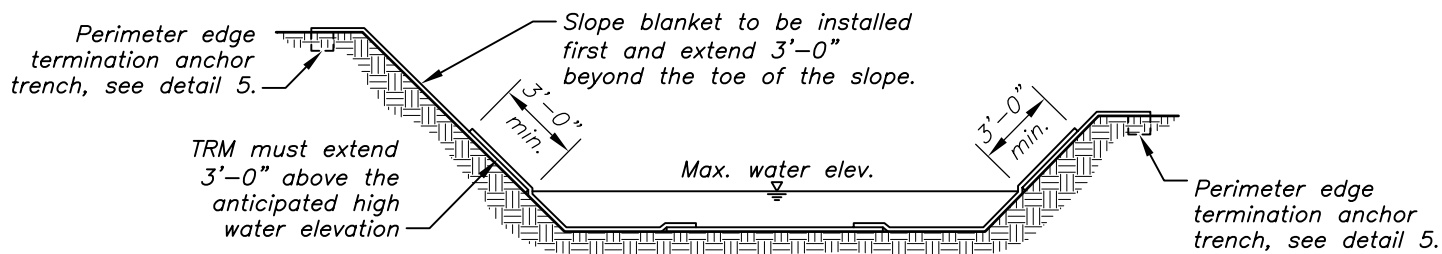
TURF REINFORCEMENT MAT FOR CHANNEL

CHANNEL DETAIL

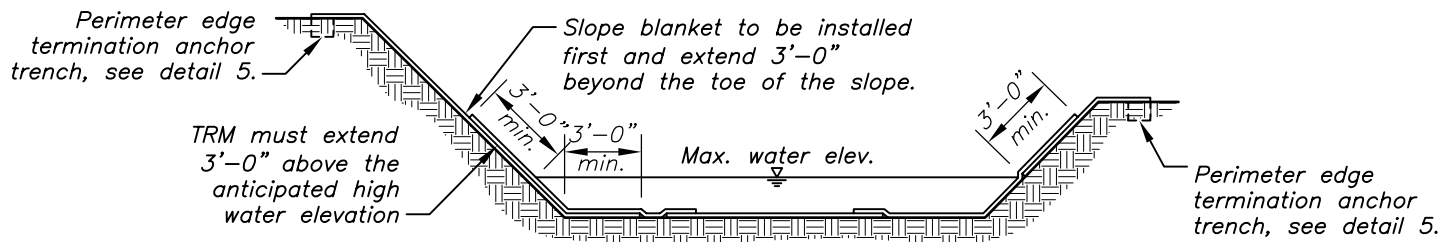
NO SCALE

NOTES:

1. Staple patterns are dependent on site conditions. See sheet 721-5, Staple Pattern Guide for details.
2. An erosion check shall be installed if distance between header trench and downstream end trench exceeds 100 feet for slopes of 5:1 or flatter or 50 feet for slopes steeper than 5:1.
3. For details 1 through 5, see sheet 721-3.

CHANNEL INSTALLATION METHOD A

NO SCALE

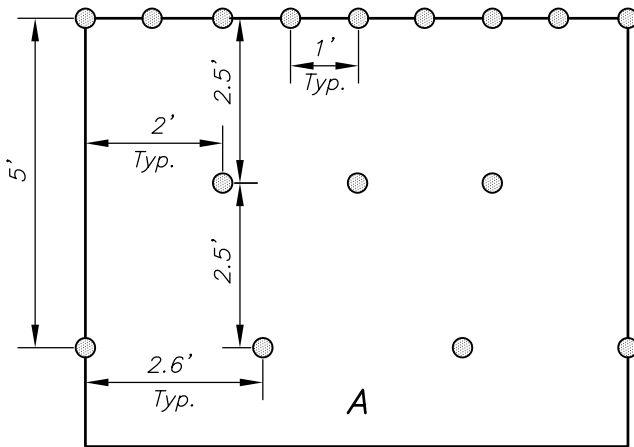
CHANNEL INSTALLATION METHOD B

NO SCALE

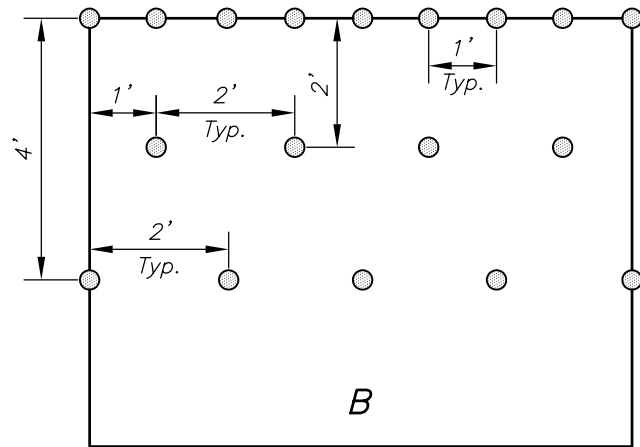
TURF REINFORCEMENT MAT (TRM) STAPLE PATTERN GUIDE

	<i>SLOPE</i>		<i>CHANNEL</i>	
	<i>1.5:1 or Flatter</i>	<i>Steeper than 1.5:1</i>	<i>Low Flow V=8.0 fps or less</i>	<i>High Flow V=More than 8.0 fps</i>
<i>Staple Pattern</i>	<i>A</i>	<i>B</i>	<i>B</i>	<i>C</i>

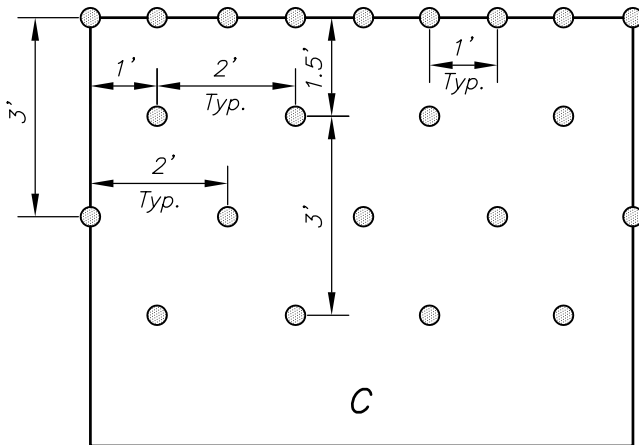
⊙ = Staple placement



2.3–2.5 STAPLES/YD²



3.0 STAPLES/YD²



4.0 STAPLES/YD²

NOTES:

1. For cohesive soil, use a 6"x1"x6" 11 gauge wire staple and for non-cohesive soil, use a 8"x2"x8" 11 gauge wire staple.
2. Equivalent stapling patterns may be used as approved by engineer.
3. For staple spacing in header, erosion check and footer trench, see sheet 721-3.